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SUMMARY OF DOCTORAL THESIS

Name: ANDRY HENINTSOA
RAVOLONANTENAINA

Title: **Acid Soil Erosion and Its Improvements**

酸性土壌の水食とその改良

Soil erosion, a natural process that can be accelerated dramatically by human activities, is viewed as the most widespread form of soil and land degradation. It is believed widely to be a major threat to sustainable crop production, if not the long-term viability of agriculture in general. The major causes of soil degradation are deforestation and removal of natural vegetation, overgrazing, improper agricultural practices, and over-exploitation of natural vegetation. Soil erosion is particularly problematic in tropical countries because of high rainfall intensities and generally less fertile soils. However, the scarcity of basic data on land resources and soil quality is a major problem, particularly when considering the island's diverse landforms and soils, and the vast extent of severe soil erosion in Madagascar. However, the red coloration of stream and river, which comes from the recently name of the island as "Great Red Island", caused by the siltation of red lateritic from the exposed hillside, provides more evidence of the severity of soil erosion in the island. In fact, there is a lack of scientifically base information on historical extents, in particularly rate and processes of soil erosion, which may lead to an oversimplified understanding of present problems. Based on the soil properties in this island, a study on the characteristics of acid soil under simulated rainfall of 30 and 60 mm h^{-1} rainfall intensity was carried out at Arid Land Research center. This study includes the following three parts:

In the first part, soil erosion from soil acidified with HNO_3, H_2SO_4, and mixture of these two acids was studied under simulated rainfall. Three different types of acid soils were prepared by mixing the soil material ≤ 2 mm with 2 *N* pure H_2SO_4, 2*N* pure HNO_3, and a mixture of 2 *N* pure H_2SO_4 and 2 *N* pure HNO_3, using tap water of 70 liters. The rainfall simulation results showed that the incremented sediment concentration (SC) with rain depth indicates a qualitatively different pattern as a result of the type of soil acidification. It could be the result of difference in the mechanisms of soil aggregate break down as determined by the electric repulsive force among soil particles, which in turn is a function of an absolute value of the surface potential of the clay or of ion concentrations or valency of the counterion. The results showed that the soil aggregate stability was affected by the ratio of water soluble Al^{3+} to its exchangeable form, which in turn had negative impact on the aggregate size of the soil erosion. There seems to be a negative interaction between the infiltration and/or water transport processes and soil erosion in soil acidification as influenced by the soil aggregate stability.

The second part was to investigate the physical mechanism involved in surface runoff (SR) and sediment (SD) generation processes in a simulated acid sulfate soil. Three different types of soil pH were prepared by mixing the soil material ≤ 2 mm with 2 *N* pure H_2SO_4, 1*N* H_2SO_4, and 0 *N* H_2SO_4 using tap water of 70 liters. The results showed that time incremented SR and sediment (SD) generation from a simulated acid soil are

characterized by three phases indicating different soil factors or mechanism controlling the different phases. We show these three phase processes can be mathematically described by a time dependent elongated S-shape curve, highlighting the factors or mechanism controlling the different phases varied with time. Soil acidity and rain intensity modified the parameters of functional relationships of the curves indicating the factors/mechanism controlling SR and SD generation processes. The infiltration limited SR or SD phase is represented by the lower horizontal segment of the curve (Phase I). The infiltration and unsaturated hydraulic conductivity (Kus) limited SR or SD phase by the rapidly increasing linear segment (phase II) and the saturated hydraulic conductivity (K_W) limited phase (phase III) by the upper horizontal segment. Larger the proportion of the smaller size particles in aggregate size distribution smaller was infiltration, Kus, and K_W that affected SR and SD. The smaller size particles are associated to surface seal, pore-clogging, pore size reductions. The generation of larger proportion of smaller size particles is controlled by the soil use management variable such as soil organic carbon (SOC). Thus we conclude greater emphasis should be placed in the maintenance of SOC in acid soils to reduce acidity induced increases in SR and SD, and consequently for long term sustainable use of the soil resource.

In the third part, the effects of amendments and vegetative cover on natural acid soil erosion were studied. Acid clay loam was taken from Yamaguchi prefecture was used in this study. The soil was amended with 10 and 15 % for Ca type artificial zeolite and 0.5 and 5 % for hydrated lime. *Sedum sediforme* (*Rupestria* group) was used as live surface. The plants were spread on the soil surface during root initiation. Three vegetative cover of 0, 25 and 75 were applied on the soil surface. The three aforementioned vegetative covers were allowed to grow on the untreated and treated acid soils for five months under irrigation at two-day intervals and at an air temperature of 25 °C before rainfall simulation experiment. The rainfall simulation results showed that the incorporation of artificial zeolite and hydrated lime decreased SR and sediment concentration (SC) in SR and the magnitude of reduction become higher as the rate of amendment increased. From our results we conclude that the reductions in SR and SC is associated with increase in aggregate stability, particularly the fractions > 500 μm and < 2000 μm. The incorporation of artificial zeolite and hydrated lime decreased also SR and soil losses in SR by the rain splashing and the magnitude of reduction become higher when another pre-treatment with irrigation for five months was applied before subjecting the samples to simulated rainfall. However, it was found that application of amendments induced also the aggregate size ≤ 106 μm that are mostly responsible for crusting. As a result, the amendment induced reduction in SR was confined to the first two phases which lasted for approximately the first 45 minutes. On the other hand, sedum cover increased significantly surface runoff; however, it decreased significantly the SC, soil loss and total soil loss by rain splash. The particle size distribution of the soil sediment, and soil splash was changed significantly, which led to decrease in the proportion of silt and clay which is mostly responsible for crusting the soil surface. The improvement of mean weight diameter of sediment carried through runoff with vegetative cover subjected to two rainfall intensities could be expressed by a mathematical relation with high degree of reliability. Hereby, implementation of acid soil-conservation measures against water erosion may be improved by knowledge about surface runoff and soil loss patterns, which are related to the characteristics of soil erosion involved.